Space Weather Technical Forecast

Issued on Friday, 12 January 2024 at 12:07 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Daily Chance of M-class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as recorded by GOES16, has been Moderate over the past 24 hours, with occasional low-level M-class flares. The largest of these was an M1.5 observed at 11/1752UTC from AR3539 in the northwestern quadrant, however the bulk of these larger flares were from Ex-AR3536 on the northwestern limb.

There are now up to eleven sunspot regions on the disc, including up to four unnumbered eastern solar hemisphere groups - as AR3543 and AR3546 faded from view near the western limb. All of the unnumbered regions on the disc grew in the period, most notably a Dro/Beta in the northeast which developed penumbral spots.

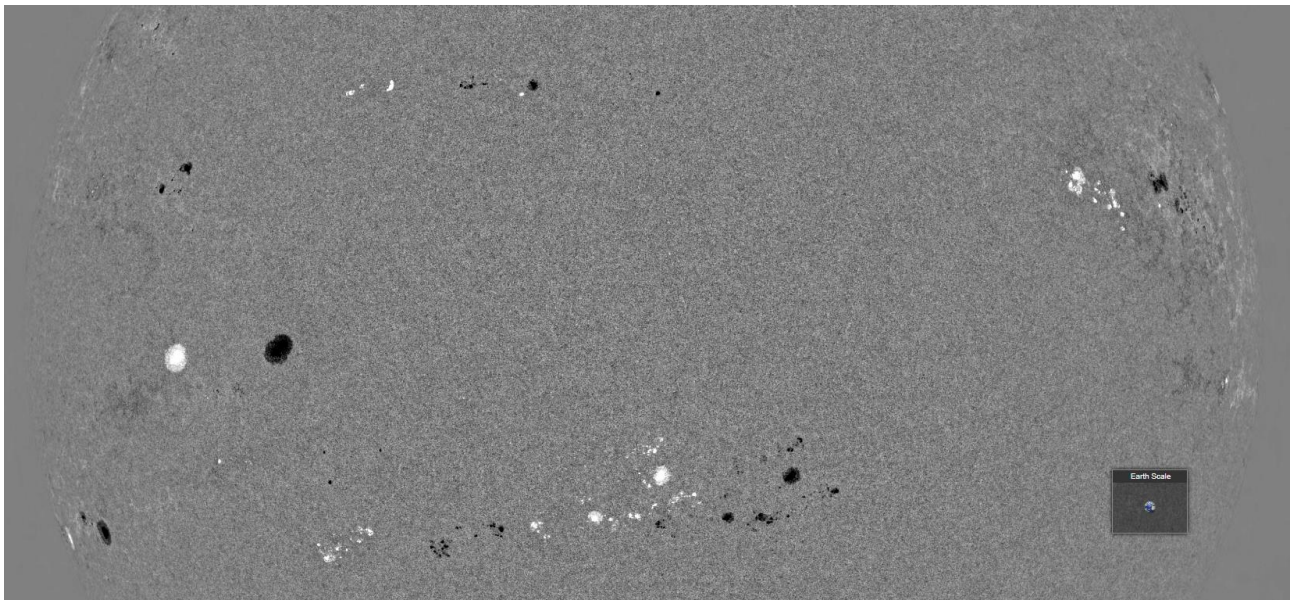

Figure 0: Helioviewer.org-processed 24-hour difference in HMIIF footprint to 12/1145UTC, showing the main changes in all front-sided sunspot groups in the period (white evolving to black). Perhaps most significant is AR3539 in the northwest in terms of activity, however AR3540 and AR3541 crossing the south-centre warrant monitoring attention. Earth shown for scale lower right.

Current sunspot regions are well-spread across the facing side AR3547 saw a spreading trend, becoming more open, with AR3539 further west both spreading and developing many internal spots to become one of the more complex on the disc at a Dai/Beta. Perhaps the most complex and changed region in the period was AR3540 near the south-centre, which forms a close pairing with AR3541 to its immediate east, which complicates how these groups are sub-divided. Treated as a pair, there was proliferation and spreading in the southwestern-most spots, with this more dynamic area perhaps a better fit to AR3541 to give both groups negative polarity leaders.

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There were a few potential Coronal Mass Ejection (CME) progenitors in the period - chronologically these were: a high northeast filament eruption around 11/1230UTC; a narrow flare-associated eruption from the western solar hemisphere at 11/1900UTC; a large prominence leaving the eastern limb at 12/0300UTC; and a very similar narrow CME from the west at 12/1000UTC. None of these events are currently thought to carry trajectories intersecting the Sun-Earth line, and there was therefore no evidence of any new Earth-bound CMEs.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by DSCOVR and ACE at L1, on average showed a Slightly Elevated character that has been ongoing since the UTC day of 08 January. The cause of this slight enhancement is not immediately clear, however the drawn-out and muted behaviour and mainly positive (away from the Sun) phi angle perhaps suggests marginal CH89/+ (which has now long-cleared the visible disc) may be a possible culprit. Whatever the cause, this feature terminated with a Solar Sector boundary Crossing (SSBC) at 12/0630UTC to little geomagnetic fanfare.

The solar wind speed showed a very different tendency between ACE and DSCOVR, but ACE's mid-400s of km/s is perhaps preferred, with the solar wind density declining within typical single-figures ppcc. The IMF showed a slight decline from 5nT within Background levels, with the north-south component erratic in character but remaining within a modest +/-4nT range.

The net result of the above solar wind measures was for provisionally Quiet geomagnetic activity throughout, with Kp peaking at '2+' in the 12-15UTC interval.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux declined to Background levels.

GOES16 high energy (greater than 2MeV) electron flux was at Normal Background levels at GEO. The associated 24-hour fluence was well below Active throughout. The 12/0001UTC 24-hour integrated fluence observation was 1.71e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of further M-class activity and a Slight Chance of X-class, declining slightly with the departure of recent more active regions.

Solar Wind / Geomagnetic Activity: No fast winds feature in the forecast period, and geomagnetic activity may therefore remain quiet throughout. The greatest chance of departures from this state of affairs is a possible glancing blow from a CME that left the Sun on 09 Jan as southeastern filament eruption. This is the rationale for the Slight Chance of G1 in the UTC day of Saturday 13 January on an otherwise Quiet forecast.

Energetic Particles / Solar Radiation: High energy proton flux will most likely remain at Background levels through the period, but with an ongoing daily Slight Chance of seeing increases to S1 minor solar radiation storm threshold given any notable flares.

The high energy electron flux is forecast to persist at Normal Background, and fluence below Active given the dearth of potential influences in the forecast period.

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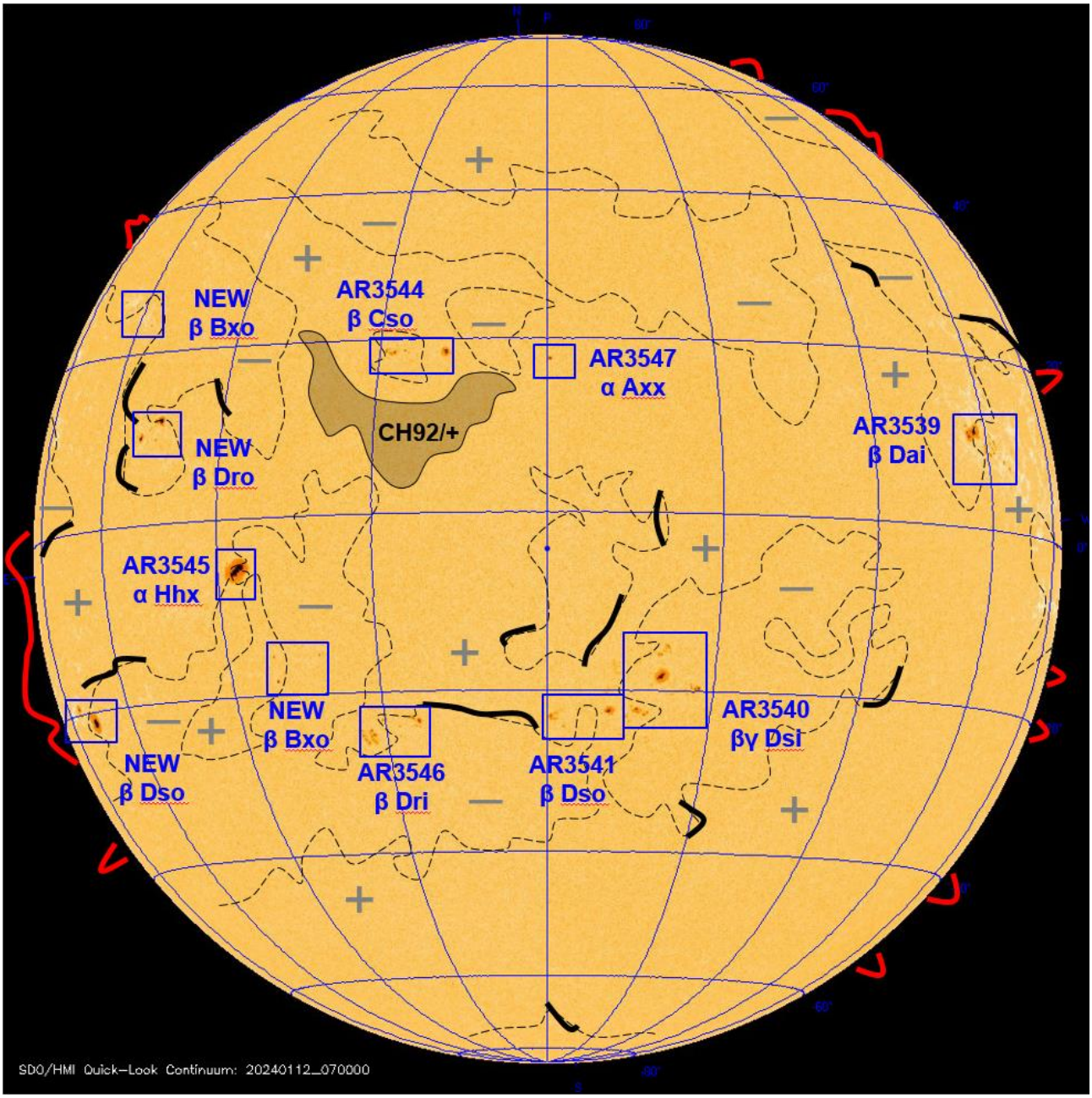
Figure 1. Solar Analysis Valid 12/0700UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Despite a large number of minor CMEs manifesting in available coronagraph imagery, these are generally felt to lie off the Sun-Earth line to play no part in the forecast. The one possible exception to this is a possible glancing blow from a CME from 09 Jan southeastern filament eruption. This is the rationale for the Slight Chance of G1 in the UTC day of Saturday 13 January on an otherwise Quiet forecast.

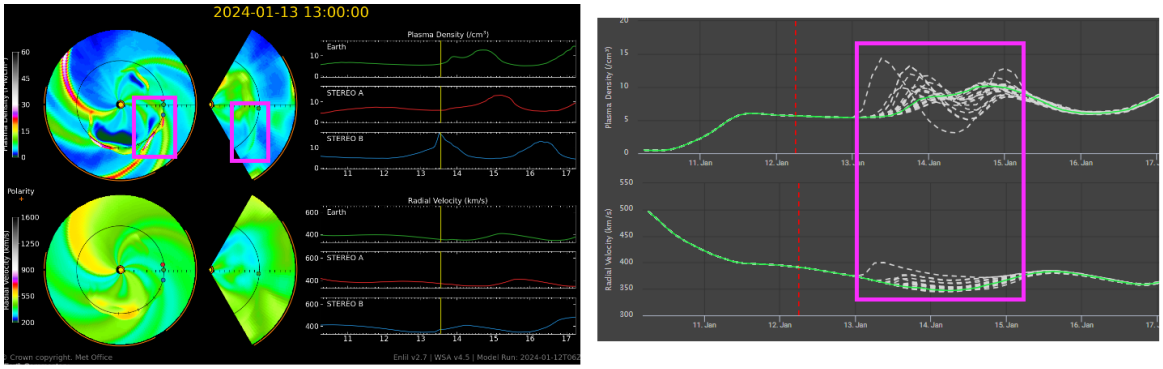
The above complication notwithstanding, no fast winds feature in the forecast period, and geomagnetic activity may therefore remain Quiet throughout.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	5	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2240	Partial?	Filament	SE	530	Crosses 1AU 13 January, most likely miss.	Any arrival liekly to be weak.

Figure 2: Latest MOSWOC Enlil run with ensemble (badge time 12/0600UTC), showing boxed magenta the sole possible inbound CME. This was associated with a southeastern filament eruption on 09 January – the deterministic run – most favoured – is a miss, however a vestigal slight chance of G1 is maintained in case some of the significant minority of solutions prove correct in a glancing blow on 13 January.



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Radio Blackouts - X-Ray Flares:

The main source for recent M-class activity has been the departing Ex-AR3536 on the northwestern limb, with AR3539 following around three days behind. The risk is otherwise well-spread across the facing side, and carries the prospect of being bolstered progressively from over the eastern limb through the UTC weekend at least, with returning Carringtons, far-side soundings and EUV east limb flux all suggesting there are prospective returning regions waiting in the wings.

The current X-ray probabilities reflect the off-going larger groups' departure (both the imminent Ex-AR3536 leaving in adjusting all days downwards from 'Likely' to a 'Chance' relative to recent guidance); and also from AR3539 following suit at the very start of the new UTC working week. Any reinforcement from the east limb will be factored in as and when regions present for analysis.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	45	45
Very Active	R3 to R5 X Class	No	5	5	1	1

Figure 3: Past 24 hours of X-ray flares at or in excess of C-class at PROBA2 – processing courtesy of SIDC ROB. Note that although there are many sources, Ex-AR3536 on the northwest limb and AR3539 are providing the weight of actvity.

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Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is now at Background levels. Any further notable flares will bring a risk of proton flux rising, with the western limb currently the most prolific in terms of potential flares from prone locations.

Overall, there is a continuing daily Slight Chance of reaching the S1 Minor Radiation Storm threshold, with the regular cadence of sunspot regions moving through prone locations as others leave serving to keep the risk roughly constant for all days.

Please note: GOES18 is currently being used as the primary proton instrument, with GOES16 data currently viewed as unreliable due to a fault reported by NOAA.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as measured by GOES16 at GEO is currently at Normal Background levels, and in the absence of any significant enhancement is expected to persist at this level throughout the four days. The associated 24-hour fluence is therefore expected to remain below the Active threshold.

MOSWOC REFM output maintains fluence at least a decade below Active throughout the next 72 hours. Even with possible glancing incidence of the 09 January CME slightly complicating matters, the most likely forecast remains a miss and REFM's thoughts are likely to be accurate.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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